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Review

Cognitive training: How can it be adapted for surgical education?

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ABSTRACT

Background: There is a need for new approaches to surgical training in order to cope with the increasing time pressures, ethical constraints, and legal limitations being placed on trainees. One of the most interesting of these new approaches is "cognitive training" or the use of psychological processes to enhance performance of skilled behaviour. Its ability to effectively improve motor skills in sport has raised the question as to whether it could also be used to improve surgical performance. The aim of this review is to provide an overview of the current evidence on the use of cognitive training within surgery, and evaluate the potential role it can play in surgical education.

Methods: Scientific database searches were conducted to identify studies that investigated the use of cognitive training in surgery. The key studies were selected and grouped according to the type of cognitive training they examined.

Results: Available research demonstrated that cognitive training interventions resulted in greater performance benefits when compared to control training. In particular, cognitive training was found to improve surgical motor skills, as well as a number of non-technical outcomes. Unfortunately, key limitations restricting the generalizability of these findings include small sample size and conceptual issues arising from differing definitions of the term 'cognitive training'.

Conclusions: When used appropriately, cognitive training can be a highly effective supplementary training tool in the development of technical skills in surgery. Although further studies are needed to refine our understanding, cognitive training should certainly play an important role in future surgical education.

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Introduction

The world of surgical training is changing. Both the standards expected and demands made of surgical trainees are higher than ever before, and consequently the efficiency of surgical education has come under increasing scrutiny. The traditional approach of 'see one, do one, teach one' that underpins apprenticeship style teaching has always been the mainstay of surgical education. More recently, however, it is increasingly accepted that this is no longer the optimum way to deliver surgical training.[1] Simultaneously, there has been a growing understanding of the cognitive demands placed on surgeons.[2,3] As a result of such scrutiny, cognitive abilities such as problem solving and movement-planning have been highlighted as playing a crucial role in skill learning.[3,4] These factors have resulted in a shift *away* from teaching that exclusively trains the motor skills required to carry out a surgery, and *towards* training that targets the thought processes of surgical trainees. The performance benefits of cognitive training have been firmly established in sport,[5,6] whilst studies in rehabilitative medicine have recognized its ability to develop motor skills.[7] These findings have raised questions concerning the degree to which cognitive training can play a role in surgical education, and furthermore, how it can be integrated optimally into surgical training programs.

What is cognitive training?

"Cognition" is a generic term used to describe the mental activities associated with thinking, learning, and memory.[8,9] In its most essential form it is our ability to mentally process and manipulate information from the world around us. 'Cognitive skills' describes the various different components that make up a person's cognition, identifying them as separate mental abilities depending on their function. As the link between cognitive skills and performance became increasingly understood,[10,11] it was theorised that training targeted at developing cognitive skills would produce improvements in motor ability. Cognitive training aims to develop or alter the way in which we mentally manipulate information, in order to improve physical performance.

The scientific basis for cognitive training resides on Jeannerod's simulation theory[12,13] and has been explored through the use of functional neuroimaging. This theory hypotheses that the motor system is part of a cognitive network that includes various psychological activities. Initial functional MRI investigations have shown that similar neural pathways are activated during cognitive training and actual performance of a task.[12,14] Furthermore, a study by Debarnot et al. found that the brain changes resulting from cognitive training for a specific motor task mimic those observed after physical practice of the same skill.[12,15] These findings help to explain why cognitive training can directly improve motor performance, and are discussed in 'Expertise and Mental Practice' by A. Moran,[12] who summarizes that, not only does cognitive training 'induce neuroplasticity, but it also elicits task-specific, practice-induced cerebral activity'.

Recent development of cognitive training has seen several distinct branches emerge. At the forefront of research is the application of "mental imagery", defined as a mental simulation process which allows a person to represent a perceptual, multi-sensory scenario in their mind, without any actual sensory input.[16] This skill is applied in the form of mental rehearsal, where a motor task is rehearsed in the mind without actual physical movement. It often relies on a mental imagery script, which consists of sensory descriptions of what a person will see, feel, and think during a task. Research has demonstrated mental rehearsal to be an extremely effective method for training elite athletes and musicians, benefitting both motor and non-technical skills.[5,12] Another area of cognitive training that is gaining popularity is the concept of 'cognitive task analysis (CTA)' based interventions; a training method by which the intuitive knowledge and thought-processes of experts are used to construct a teaching program for novices.[17] CTA uses interview and observation methods to elicit the automated skills, strategies, and decisions that underlie expert performance.[18] This allows a task to be broken down into manageable steps that provide both technical and cognitive instructions, and has been proven as an effective teaching method in military and aviation settings.[6] Possibly the most popularly publicized field of cognitive training is 'brain training', which uses the repetition of short tasks or games to exercise specific cognitive functions, and has become a multi-million pound industry.[19] Other types of cognitive training are less well defined and often revolve around structured problem solving, interactive teaching, and development of critical evaluation skills.[20]

Cognitive training in use

Cognitive training has been utilized within sport for many years and has become an important tool used by athletes at the elite level. Studies have shown that cognitive training can improve a variety of different motor skills in sport, as well as skill acquisition and physical strength.[5] It can also increase an athlete's overall performance by improving specific mental processes such as reaction and movement planning.[5,11] Mental rehearsal is perhaps the most widely applied performance-enhancement technique in sports, with a meta-analysis by Feltz et al.[21] finding that the average effect size of mental practice was 0.47, compared to an average effect size of 0.22 in the control groups. A randomized controlled trial of 183 tennis players found that the use of mental rehearsal gave a significant improvement in the execution of the forehand drive and concluded it was effective at enhancing motor performance in athletes.[22] Evidence also supports the use of techniques such as CTA[6] and computer-based cognitive simulation.[23] Another field that has embraced cognitive training is the aviation industry. Mauro et al.[24] noted that pilots are required not simply to remember the relevant information, but more importantly process and apply this knowledge effectively in the operational environment. A pioneering study done by Prof. D Gopher used a cognitive simulator to train pilots and found that it resulted in a record improvement in overall flight performance of more than 30%.[25] Cognitive training is now consistently integrated into aviation programs, commonly in the form of cognitive simulators.[26]